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ABSTRACT

One of twelve water treatment technology units, this student manual on pumps provides instructional materials for three competencies. (The twelve units are designed for a continuing education training course for public water supply operators.) The competencies focus on the following areas: types of pumps in plant and distribution systems, pump maintenance checks, and pump repair. For each competency, student objectives, resources (appendixed materials), learning activities, and an evaluation activity are provided. The appendices contain information sheets on pumps and flow controllers and pump troubles. (JH)

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AUG 21

Water Treatment Technology

# PUMPS

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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PUMPS

EVALUATOR'S COPY

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# EVALUATOR'S INSTRUCTIONS

Name _____

Address _____

_____

Phone _____

This is your EVALUATOR'S COPY of the PUMPS unit. It contains all of the materials received by the operators who will be working on the unit. It also contains *answer keys* and *directions* for the evaluation of each Competency. For each Competency Sheet, there is a COMPETENCY, a list of RESOURCES, LEARNING ACTIVITIES, and EVALUATION ACTIVITIES.

Your student operators will call you when they are ready to be evaluated. An operator may complete the evaluations in *any* order. S/he may choose to complete one at a time, or several at one time. *It is up to you and each operator to set convenient schedules for the evaluations.* It is important that the operators learn the skills listed in each competency. It is <u>your</u> job to be sure the operators can perform the competencies.

If an operator does <u>not</u> complete an evaluation correctly, s/he may try again later after practicing the skills. It would be helpful for you to tell the operators just how they should improve their knowledge and skills in order to complete the evaluation successfully. Be sure to call if you have any questions.

This package contains:

- - - - - PUMPS unit

- - - - - Evaluation Forms for each Competency

You will receive instructions as to where to send the completed evaluation forms. Please be sure that the operator's name and your name are on the forms, as well as the date on which the evaluation was performed.

## INSTRUCTIONS FOR THE STUDENT OPERATOR

The PUMPS unit contains three competencies. A "competency" is a skill that is necessary for good on-the-job performance. Each competency in this unit is necessary for you to perform on the job according to the West Virginia Department of Health. There is a Competency Sheet to help you understand each competency.

*DIRECTIONS FOR COMPLETING THE UNIT:*

1. Read each Competency Sheet carefully. Every Competency Sheet contains:

   COMPETENCY
   Objectives
   RESOURCES
   LEARNING ACTIVITIES
   EVALUATION ACTIVITY(IES)

2. After reading the whole Competency Sheet, you should understand what will be expected of you.

3. Do the LEARNING ACTIVITIES that you think will help you the most. This may include reading some of the RESOURCES which have been included with the unit.

4. If you need additional help, ask an operator in your plant for assistance, or call your evaluator; he's there to help you.

5. When you are ready to complete the EVALUATION ACTIVITY for one or more competencies--call your evaluator. The two of you will schedule the best time for your evaluation.

   a. If you complete the evaluation correctly, go on to the next competency.
   b. If you do <u>not</u> complete the evaluation correctly, your evaluator will tell you what your mistakes were. You must go back and practice your skills and read the RESOURCES again. Call your evaluator when you are ready to try again. *You must wait at least one week before being re-evaluated on a competency.*

*SEE NEXT PAGE*

6. When you complete all your evaluations correctly you will receive a Certificate of Accomplishment and 0.6 Continuing Education Units of Credit.

7. If you want to go on to another unit, contact your evaluator for the materials. The procedure will be similar for all units.

## AN EXPLANATION OF CONTINUING EDUCATION UNITS

For student operators in the OPERATOR-IN-TRAINING category who will be taking the certification examination for Class I, this course is an opportunity to increase your knowledge and competence in the treatment of water for human consumption. Successful completion of the manuals will also, it is hoped, make passing the certification exam much easier. The Continuing Education Units which you will get by taking this course will not decrease the minimum one year operating experience requirement for a Class I certificate.

For student operators who now hold a Class I certificate, the completion of all twelve manuals in the course will reduce the currently required three years of total operating experience for Class II certification by approximately four months. Thus, if you complete the course, you will need only two years and eight months of total operating experience before you take the Class II exam.

Here is a listing of the Continuing Education Unit (CEU) value of each of the manuals.

| Manual | CEU Value |
|---|---|
| General Plant Operation | 1.4 |
| Taste, Odor, and Color | 0.6 |
| Chemistry/Bacteriology | 2.5 |
| Chlorination | 2.5 |
| Fluoridation | 0.6 |
| Filtration | 1.2 |
| Hydraulics | 0.6 |
| Distribution Systems | 1.2 |
| Pumps | 0.6 |
| Wells | 1.0 |
| Cross Connections | 0.4 |
| Springs | 0.4 |
| Total | 13.0 |

For comparison with other types of training previously available, the CEU conversions below are given.

| | |
|---|---|
| Public Water Supply Operator's Short Course (given by State Department of Health Personnel) | 4 CEUs |
| One Semester Hour of College Credit | 1.5 CEUs |
| One Year of College Credits (30 semester hours) | 45 CEUs |

**COMPETENCY:** Sketch, label, and describe the various types of pumps used within your treatment plant and distribution system.

**Objective:** Identify all types of pumps used by your treatment plant.

**Objective:** Describe the purpose of each pump used by your treatment plant.

**Objective:** Sketch and label all basic parts to each pump used by your treatment plant.

**RESOURCES:**

(a) Waterworks Manual-basic, Coordinating Council for Occupational Education, State of Washington, 1972, pp. 71-79. *-Green Appendix-*

(b) Water Works Operators Manual, Bureau of Environmental Health, Alabama Department of Public Health, Third Edition, 1972, Chapter IX, pp. 13-17. *-Yellow Appendix-*

(c) Manufacturer's manual for each pump used in your treatment plant and distribution system.

**LEARNING ACTIVITIES:**

(a) Read the Resources listed above to find information about pumps.

(b) Take a "tour" of your treatment plant. Using manufacturer's manuals, identify each type of pump. Determine why each particular type of pump was selected for each location.

(c) Practice sketching each type of pump used in your treatment plant and distribution system. Artistic ability is not important. The purpose of the sketch is to help you recognize all the basic parts of the pumps. Label the parts.

**EVALUATION ACTIVITY:** Sketch, label, and describe the basic parts of each type of pump used in your treatment plant and distribution system. Label the basic parts in each sketch. You may not use references.

**COMPETENCY:** Perform a maintenance check on all pumps in your plant, keeping accurate records of your maintenance checks.

**Objective:** Identify and describe the maintenance schedule for each pump used by your treatment plant.

**Objective:** Develop a record-keeping system for pump maintenance in your treatment plant.

**Objective:** Perform a maintenance check on each pump in your plant.

**RESOURCES:**

(a) Waterworks Manual-basic, Coordinating Council for Occupational Education, State of Washington, 1972, pp. 71-79. *-Green Appendix-*

(b) Water Works Operators Manual, Bureau of Environmental Health, Alabama Department of Public Health, Third Edition, 1972, Chapter IX, pp. 13-17. *-Yellow Appendix-*

(c) Centrifugal Pump Troubles, *-Blue Appendix-*

(d) Manufacturer's manual for each pump used in your treatment plant and distribution system.

**LEARNING ACTIVITIES:**

(a) Read the Resources listed above to find information about pump maintenance.

(b) Observe an experienced operator perform maintenance checks on all types of pumps used in your plant. Make note of the procedure as well as how often each pump is checked.

(c) Review the manufacturer's manuals for each pump used by your treatment plant. Have an experienced operator observe you while you perform maintenance checks on all pumps in your plant. Keep a record of your maintenance check. Your record should include the date, and a check point for each part checked on each pump. You will probably need to make a different reusable maintenance check record form for each pump. Then you can bring the form along on every maintenance check. Be sure to include a space for "comments". You can use this space to describe any repair work that has been done or needs to be done.

**EVALUATION ACTIVITY:** You will be expected to perform a maintenance check on each type of pump used in your treatment plant and distribution system. Bring your maintenance check forms with you to record your findings for each pump. Your records must be accurate, showing the date and the parts okayed for each pump. Your records should also show when repairs are recommended or have been performed.

**COMPETENCY:** Demonstrate the ability to perform necessary repairs on the pumps within your treatment plant and distribution system.

**Objective:** Identify the various types of pumps in your treatment plant and distribution system and describe how each works.

**Objective:** Identify common repairs necessary for each type of pump used by your plant.

**Objective:** Perform necessary repairs on pumps in your treatment plant and distribution system.

**RESOURCES:**

(a) Waterworks Manual-basic, Coordinating Council for Occupational Education, State of Washington, 1972, pp. 71-79. *-Green Appendix-*

(b) Water Works Operators Manual, Bureau of Environmental Health, Alabama Department of Public Health, Third Edition, 1972, Chapter IX, pp. 13-17. *-Yellow Appendix-*

(c) Centrifugal Pump Trouble, *-Blue Appendix-*

**LEARNING ACTIVITIES:**

(a) Read the Resources listed above to find information about performing pump repairs.

(b) Observe an experienced operator or pump mechanic perform repairs on pumps in your treatment plant and distribution system. Make note of the procedures followed and the tools used.

(c) If available, review past maintenance check records for pump repairs in your plant. Notice the type of repairs done on the pumps. Also note the frequency of repairs.

(d) Under the supervision of an experienced operator, perform necessary repairs on any pump(s) in your system in need of them. Follow manufacturer's instructions carefully. Be sure to keep accurate records of the repairs you perform.

**EVALUATION ACTIVITY:** You will be expected to identify and perform necessary repairs on a pump in your treatment plant or distribution system. You must keep accurate records of the repair. Use the manufacturer's manual as a reference.

# PUMPS AND FLOW CONTROLLERS*

The use of pumps to transport water, increase pressures, feed chemicals for treatment processes, and other uses is common practice in most water systems. The operation and maintenance of pumps and flow controllers are some of the most important duties of waterworks operators. Different types of pumps and controllers may be used, each with characteristics that adapt the mechanism to the particular use desired.

## Types of Common Pumps

### *Centrifugal Pumps*

Centrifugal pumps are the most commonly used type for pumping water. They operate on the principle of centrifugal force; water is drawn in at the center of a rotating impeller and is forced outward by the speed of the impeller. The outward force is limited by the size, speed, and design of the impeller. For efficient operation, a centrifugal pump must be designed for the particular job it is to do.

### *Reciprocating Pumps*

Reciprocating pumps are positive-displacement units. They discharge a definite quantity of liquid during piston or plunger movement through the stroke distance. However, not all of the liquid may reach the discharge pipe because leaks or bypass arrangements may prevent this. Neglecting these, the volume of liquid displaced during one stroke of the piston or plunger is equal to the piston area times the stroke length.

### *Rotary Pumps*

Rotary pumps consist of a fixed casing containing gears, vanes, pistons, cams, segments, screws, etc., operating with minimum clearance. Instead of "throwing" the liquid as in a centrifugal pump, a rotary pump traps it, pushing it around the closed casing much like the piston of a reciprocating pump. Unlike a piston pump, however, a rotary pump discharges a smooth flow. Often thought of as viscous liquid (thick liquids like heavy oil or molasses are viscous) pumps, rotaries are by no means confined to this service alone. They will handle almost any liquid that is free of hard and abrasive solids.

## Pump Uses

The centrifugal pump is normally used for most large-capacity pumping installations, while the reciprocating and rotary pumps are

*Source: Waterworks Manual-basic, Coordinating Council for Occupational Education, State of Washington, 1972, pp. 71-79.

best for low-capacity, high-head uses and for chemical dosage and metering requirements.

The centrifugal pump classification includes three main types: (1) radial flow, (2) mixed flow, and (3) axial flow. The radial flow type sucks the water into the impeller next to the shaft and spins it radially outward to the pump casing. Energy is transmitted to the water while the water is moving perpendicular to the pump shaft. The axial flow (or propeller) type transmits energy to the water by the lifting or pushing action of the impeller vanes, while the water moves parallel to the pump shaft (similar to the propellers of a large ship). The mixed flow type is a cross between the radial and axial types.

Axial flow pumps generally have a large capacity rating at low heads (up to 200,000 gpm at heads from 1 to 50 ft.) and have a rotating speed that is normally less than 500 rpm. Radial flow pumps have larger capacities and higher heads (0 to 30,000 gpm and heads to 1,500 ft.) and a rotating speed up to 3,500 rpm. Mixed flow pumps have head capacities between the two extremes (500 to 100,000 gpm at 20-to 100-ft. heads) and rotate between 400 and 1,750 rpm. The normal horizontal shaft centrifugal booster pump is generally of the radial flow type. Deep-well turbine pumps are normally in the range of radial or mixed flow types. Low-head, raw-water pumps from rivers to treatment plants would more closely approximate the axial flow type.

Caution must be used in applying classifications to pumps because many factors other than those stated above have an influence on the selection of a particular pump for a particular job.

## General Pumping Terms

*Pressure*

Three terms commonly arise in discussing pressures: *absolute pressure*, which is the sum of all pressures on a fluid, *barometric pressure*, which is the instantaneous atmospheric pressure (usually measured in inches of mercury), and *gauge pressure*, which is just the pressure exerted by a fluid at the gauge location. Vacuum pressure is a term used to describe negative gauge pressure.

*Head*

Figure 1 shows three situations encountered in typical pumping installations. The head terms are as shown on the sketches.

*Static Suction Lift*

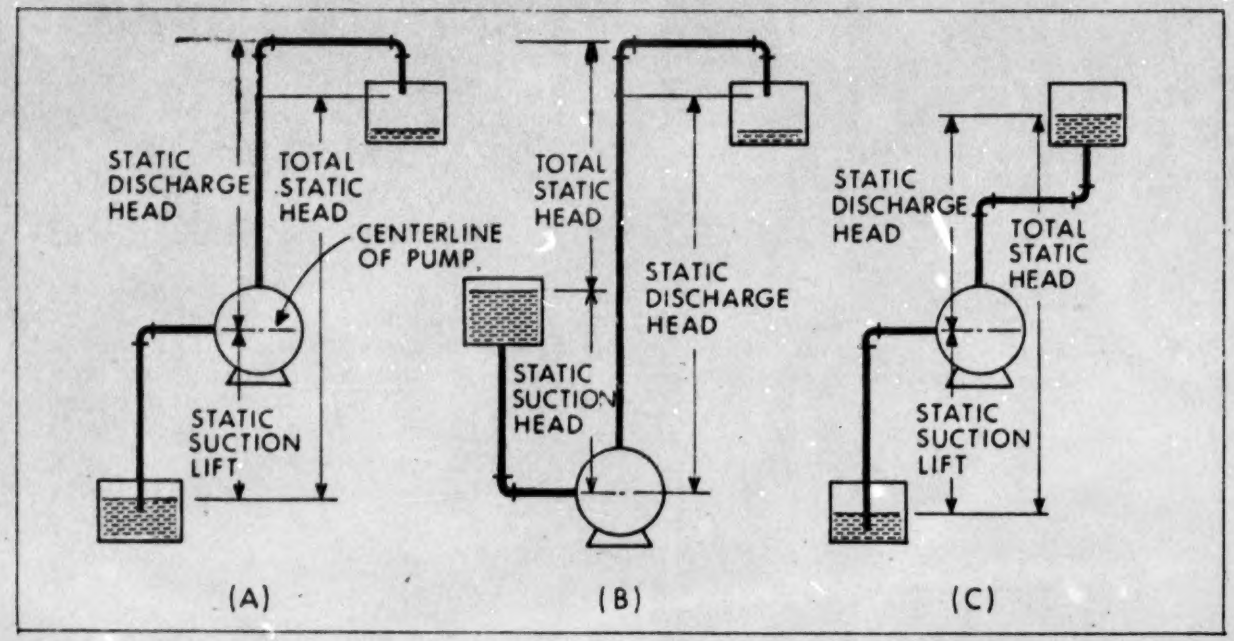
The vertical distance from the liquid supply level to the pump centerline, the pump being *above* the supply level, is static suction lift.

*Static Suction Head*

The vertical distance from the liquid supply level to the pump

Figure 1

Head Terms Used in Pumping




centerline, the pump being *below* the supply level, is static suction head.

*Static Discharge Head*

The vertical distance from the pump centerline to the point of free delivery of the liquid is static discharge head. Care must be exercised to see that the point of free delivery is used when computing static discharge head. In some layouts, the exact point may be difficult to determine.

*Total Static Head*

On a pump, total static head is the vertical distance between the supply level and the discharge level of the liquid being handled.

*Friction Head*

Friction head is measured in feet of the liquid handled and is the equivalent head needed to overcome the resistance of the pipe, valves, and fittings in the pumping system. Friction head exists on both the suction and discharge sides of a pump and varies with liquid flow rate, pipe size, interior condition of the pipe, type of pipe, and nature of the liquid being handled.

*Velocity Head*

Velocity head is the vertical distance a liquid must fall to acquire the velocity with which it flows through the piping system. For a given quantity of flow, the velocity head will vary indirectly as the pipe diameter varies.

*Entrance and Exit Losses*

Entrance and exit losses are head losses occurring at the piping system entrance and exit. Similar losses also occur at abrupt changes in piping sizes.

*Suction Lift*

Suction lift is the sum of the static suction lift, the suction friction head, and the entrance loss in the suction pipe. The suction friction head includes the friction in the pipe and all fittings in the suction line.

*Suction Head*

Suction head is the static suction head minus the suction friction head and suction piping entrance loss.

*Discharge Head*

Discharge head is the sum of the static discharge head, the discharge friction head, and the discharge velocity head.

*Total Head*

Total head is the sum of the suction lift and the discharge head. Where there is a suction head, the total head on the pump is the difference between the discharge and suction heads.

Pump Characteristics Curves

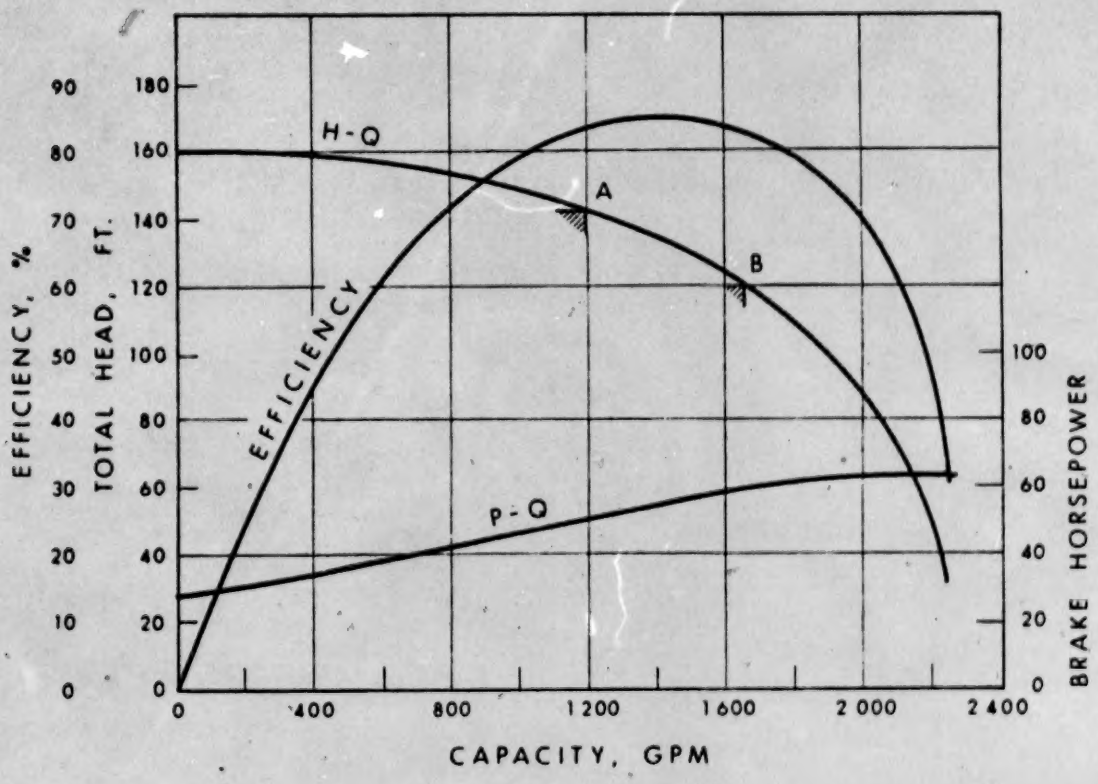
A centrifugal pump operated at constant speed delivers any capacity from zero to a maximum, depending on the head, design, and suction conditions. Characteristic curves show the interrelation of pump head, capacity, power, and efficiency for a specific impeller diameter and casing size. It is usual to plot head, power, and efficiency against capacity, as in Figure 2. The head-capacity curve, labeled H-Q, shows the relation between capacity and total head, and may be rising, drooping, steep, or flat, depending on the impeller type and its design. At A in Figure 2, the head developed by the pump is 144 ft. of water, at 1,200 gpm capacity. At B, where the head is 120 ft., the capacity of the pump rises to 1,680 gpm. Power requirements for a given point on the H-Q curve can be obtained by reading the P-Q curve at the same capacity reading, and efficiency is obtained in the same manner.

Reciprocating pumps have varying rates of discharge due to the eccentric action of the piston and flywheel. The exact manner of

pulsation is also dependent upon the cushion chamber, which is used to even out the flow rate. Duplex and triplex pumps (two or three pistons operating in a staggered order, as in an automobile engine) are also used to even out the flow.

Figure 2

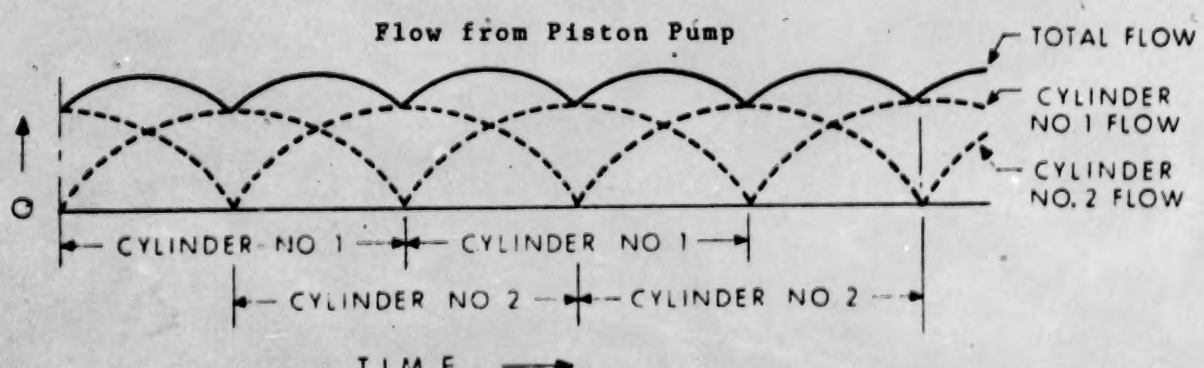
Typical Characteristic Curves for Centrifugal Pump




Head limitations are generally based only on the strength of the pump casing and on the horsepower available to drive the pistons. A two-cylinder piston pump would produce flow pulsations as shown in Figure 3.

Figure 3

Flow from Piston Pump



Rotary pumps deliver almost a constant flow against varying discharge pressures. The H-Q curve becomes almost a horizontal line, and total discharge varies with the speed at which the gears are driven. Discharge pressures are limited by the strength of the casing and by the power available to drive the rotary pump.

When water is pumped from a lower elevation to a higher one, energy is required. The horsepower represented on a theoretical basis is:

$$HP = \frac{HQ}{3,960}$$

where H = head in feet
Q = quantity in gallons per minute

Table I is set up to solve this equation. For example, if it is desired to pump 150 gpm at 100 ft. of head, the theoretical horsepower is 3.75. In general, however, there is loss in efficiency through the pump and motor so that a larger power source is needed. If the system is 80% efficient, the needed horsepower is 3.75/0.80 = 4.7, so a 5-HP motor would probably be used.

## TABLE I

## THEORETICAL HORSEPOWER REQUIRED TO RAISE WATER TO DIFFERENT HEIGHTS

| Feet | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 60 | 75 | 90 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 | Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gals. per Min. | | | | | | | | | | | | | | | | | | | | | | | Gals. per Min. |
| 5 | .006 | .012 | .019 | .025 | .031 | .037 | .043 | .05 | .06 | .06 | .07 | .09 | .11 | .12 | .16 | .19 | .22 | .25 | .31 | .37 | .43 | .50 | 5 |
| 10 | .012 | .025 | .037 | .050 | .062 | .075 | .087 | .10 | .11 | .12 | .15 | .19 | .22 | .25 | .31 | .37 | .44 | .50 | .62 | .75 | .87 | 1.00 | 10 |
| 15 | .019 | .037 | .056 | .075 | .094 | .112 | .131 | .15 | .17 | .19 | .22 | .28 | .33 | .37 | .47 | .56 | .66 | .75 | .94 | 1.12 | 1.31 | 1.50 | 15 |
| 20 | .025 | .050 | .075 | .100 | .125 | .150 | .175 | .20 | .22 | .25 | .30 | .37 | .45 | .50 | .62 | .75 | .87 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 20 |
| 25 | .031 | .062 | .094 | .125 | .156 | .187 | .219 | .25 | .28 | .31 | .37 | .47 | .56 | .62 | .78 | .94 | 1.09 | 1.25 | 1.56 | 1.87 | 2.19 | 2.50 | 25 |
| 30 | .037 | .075 | .112 | .150 | .187 | .225 | .262 | .30 | .33 | .37 | .45 | .56 | .67 | .75 | .94 | 1.12 | 1.31 | 1.50 | 1.87 | 2.25 | 2.62 | 3.00 | 30 |
| 35 | .043 | .087 | .131 | .175 | .219 | .262 | .306 | .35 | .39 | .43 | .52 | .66 | .78 | .87 | 1.09 | 1.31 | 1.53 | 1.75 | 2.19 | 2.62 | 3.06 | 3.50 | 35 |
| 40 | .050 | .100 | .150 | .200 | .250 | .300 | .350 | .40 | .45 | .50 | .60 | .75 | .90 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 40 |
| 45 | .056 | .112 | .169 | .225 | .281 | .337 | .394 | .45 | .51 | .56 | .67 | .84 | 1.01 | 1.12 | 1.41 | 1.69 | 1.97 | 2.25 | 2.81 | 3.37 | 3.94 | 4.50 | 45 |
| 50 | .062 | .125 | .187 | .250 | .312 | .375 | .437 | .50 | .56 | .62 | .75 | .94 | 1.12 | 1.25 | 1.56 | 1.87 | 2.19 | 2.50 | 3.12 | 3.75 | 4.37 | 5.00 | 50 |
| 60 | .075 | .150 | .225 | .300 | .375 | .450 | .525 | .60 | .67 | .75 | .90 | 1.12 | 1.34 | 1.50 | 1.87 | 2.25 | 2.62 | 3.00 | 3.75 | 4.50 | 5.25 | 6.00 | 60 |
| 75 | .094 | .187 | .281 | .375 | .469 | .562 | .656 | .75 | .84 | .94 | 1.12 | 1.40 | 1.69 | 1.87 | 2.34 | 2.81 | 3.28 | 3.75 | 4.69 | 5.62 | 6.56 | 7.50 | 75 |
| 80 | .100 | .200 | .300 | .400 | .500 | .600 | .700 | .80 | .90 | 1.00 | 1.20 | 1.50 | 1.80 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 80 |
| 90 | .112 | .225 | .337 | .450 | .562 | .675 | .787 | .90 | 1.01 | 1.12 | 1.35 | 1.69 | 2.02 | 2.25 | 2.81 | 3.37 | 3.94 | 4.50 | 5.62 | 6.75 | 7.87 | 9.00 | 90 |
| 100 | .125 | .250 | .375 | .500 | .625 | .750 | .875 | 1.00 | 1.12 | 1.25 | 1.50 | 1.87 | 2.25 | 2.50 | 3.12 | 3.75 | 4.37 | 5.00 | 6.25 | 7.50 | 8.75 | 10.00 | 100 |
| 125 | .156 | .312 | .469 | .625 | .781 | .937 | 1.09 | 1.25 | 1.41 | 1.56 | 1.87 | 2.34 | 2.81 | 3.12 | 3.91 | 4.69 | 5.47 | 6.25 | 7.81 | 9.37 | 10.94 | 12.50 | 125 |
| 150 | .187 | .375 | .562 | .750 | .937 | 1.125 | 1.312 | 1.50 | 1.69 | 1.87 | 2.25 | 2.81 | 3.37 | 3.75 | 4.69 | 5.62 | 6.56 | 7.50 | 9.37 | 11.25 | 13.12 | 15.00 | 150 |
| 175 | .219 | .437 | .656 | .875 | 1.093 | 1.312 | 1.531 | 1.75 | 1.97 | 2.19 | 2.62 | 3.28 | 3.94 | 4.37 | 5.47 | 6.56 | 7.65 | 8.75 | 10.94 | 13.12 | 15.31 | 17.50 | 175 |
| 200 | .250 | .500 | .750 | 1.000 | 1.250 | 1.500 | 1.750 | 2.00 | 2.25 | 2.50 | 3.00 | 3.75 | 4.50 | 5.00 | 6.25 | 7.50 | 8.75 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | 200 |
| 250 | .312 | .625 | .937 | 1.250 | 1.562 | 1.875 | 2.187 | 2.50 | 2.81 | 3.12 | 3.75 | 4.69 | 5.62 | 6.25 | 7.81 | 9.37 | 10.94 | 12.50 | 15.62 | 18.75 | 21.87 | 25.00 | 250 |
| 300 | .375 | .750 | 1.125 | 1.500 | 1.875 | 2.250 | 2.625 | 3.00 | 3.37 | 3.75 | 4.50 | 5.62 | 6.75 | 7.50 | 9.37 | 11.25 | 13.12 | 15.00 | 18.75 | 22.50 | 26.25 | 30.00 | 300 |
| 350 | .437 | .875 | 1.312 | 1.750 | 2.187 | 2.625 | 3.062 | 3.50 | 3.94 | 4.37 | 5.25 | 6.56 | 7.87 | 8.75 | 10.93 | 13.12 | 15.31 | 17.50 | 21.87 | 26.25 | 30.62 | 35.00 | 350 |
| 400 | .500 | 1.000 | 1.500 | 2.000 | 2.500 | 3.000 | 3.500 | 4.00 | 4.50 | 5.00 | 6.00 | 7.50 | 9.00 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | 25.00 | 30.00 | 35.00 | 40.00 | 400 |
| 500 | .625 | 1.250 | 1.875 | 2.500 | 3.125 | 3.750 | 4.375 | 5.00 | 5.62 | 6.25 | 7.50 | 9.37 | 11.25 | 12.50 | 15.62 | 18.75 | 21.87 | 25.00 | 31.25 | 37.50 | 43.75 | 50.00 | 500 |

## Centrifugal Pump Applications

Almost all pumps used to pump water are of the centrifugal design. The following will briefly outline some uses of the various types of centrifugal pumps.

*Deep-Well Pumps*

Multistage diffuser pumps are widely used for this type of service and are called vertical turbine pumps. These pumps are of the

mixed or radial flow type and frequently have several stages to increase the discharge head. The driving motor or engine is mounted above ground and connected to the submerged pump stages by the line shaft. The designation of open or closed line shaft merely tells whether the shaft bearings are lubricated by the water being pumped or by oil. Deep-well pumps are normally 4-in. pumps or larger and can be obtained up to about 30 in. Capacities vary from 100 gpm to 30,000 gpm.

*Submersible Pumps*

This type of pump is also a multistage diffuser pump except that the driving motor is designed for submerged service and is close-coupled directly to and below the pump. No line shafts are required. The pump is suspended in the well by a steel cable. Heads and capacities can be equal to the vertical turbine pumps but eventually are limited by the sizes of submersible motors available. Advantages include the fact that the submersible pump can be installed in wells too crooked for vertical turbine pumps; a disadvantage is that the entire pump and motor must be removed from the well for even minor repairs.

*Close-Coupled Vertical Turbine Pumps*

These pumps are similar to deep-well pumps but have much shorter pump settings. They are designed for all types of applications, ranging from high-pressure booster pumps to low-lift pumps, for service from river intakes to adjacent treatment plants. Generally, the impellers for these pumps will be more in the mixed flow or axial flow range. Some close-coupled vertical turbine pumps are mounted in short sections of pipe used for high-pressure booster service and called "can" pumps.

*General-Purpose Pumps*

The most common and popular type pump is the horizontally mounted, electric-motor-driven, centrifugal pump. Impellers can be classed as open or closed, but all are generally of the radial flow type. Pressures are dependent upon the number of stages, with one-stage pumps being the most common. Uses are too numerous to list but would include booster pump application, pressure system pumps, and any use where clear, cool liquids are to be pumped at normal temperatures.

## Regulating and Control Valves

The basic types of valves used in water systems are gate valves, check valves, globe valves, butterfly valves, and, in some cases, needle valves. Each valve is designed for a specific purpose, and should be used for its intended service.

*Isolation Valves*

Isolation valves should be located to allow a particular portion of the system to be shut off without affecting service to the remainder of the consumers. Isolation valves are located at pumps, reservoirs, treatment plants, and all throughout the distribution system. Isolation valves are intended to be entirely open or completely shut, and are not designed to be operated at intermediate positions. Gate valves and butterfly valves are the most commonly used types of valves for this purpose. Pump discharges are sometimes equipped with automatic valves to open and close when the pump starts and stops. Power-operated valves can be adapted to this service since it is essentially an open or closed type of use.

*Check Valves*

Check valves are designed to allow flow in only one direction. These valves are usually located on the discharge side of a pump to prevent water flowing backwards through the pump when the pump is not operating. Check valves are also used at certain locations in the distribution system or at reservoirs where it is desired to have single-direction flow. A simple check valve is similar to a flap valve, with the water lifting the flap when flowing through the valve. If water attempts to flow in the opposite direction, the flap closes against the valve seat and seals off the flow. Some check valves have been adapted for pump control purposes and operate similar to modulating valves.

*Modulating Valves*

Most regulating and control valves can be classed as modulating, or throttling, valves. A modulating valve is nothing more than a valve that can adjust itself to maintain the conditions desired. Pressure-reducing, pressure-relief, altitude-control, and flow-control valves all are classed as modulating valves.

A globe valve type of construction is normally used for this purpose, since it can be adjusted to fine variations in flow, while gate or butterfly valves are hard to adjust to the fine tolerances required. Needle valves are easily adjusted but are not as economical in most cases as the globe valve. In most cases, a control valve consists of a main valve for the actual control and a smaller pilot valve that senses the existing conditions of flow and "tells" the main valve to open or close as required.

Operation of a modulating valve is normally accomplished by the pressures in the pipeline, thus eliminating the need for electrical service to the valve. The globe valve is adapted to contain a diaphragm-operated valve stem. The valve opens when water is removed from the power chamber, which is the space between the diaphragm and the valve body, and closes when water is injected into the same space. Movement of the diaphragm causes the valve assembly to open and close. The control of water into this space is accomplished by one or more pilot valves, and needle valves. Clean, clear water is essential for this use to prevent plugging of the pilot valves. The pilot valve is manually adjustable by varying the force used to compress the spring.

The speed of opening and closing of the modulating valves should be controlled to prevent pressure surges and overaction of the valve. This is normally accomplished by adjusting needle valves to limit the flow of water into and from the power chamber. Valves, such as pressure relief valves, should open fast to prevent excessive pressures, but should close relatively slowly to prevent pressure surges. This can be accomplished by using different settings on the valves in the inlet and outlet lines to the power chamber.

All modulating and control valves are basically of the same principle of operation. The main globe valve can be made to perform almost any desired function by changing the location of the sensing device, the setting of the pilot valves, and the plumbing of the pilot valves and power chamber water supply and waste.

*PRESSURE-REDUCING VALVES*--The pressure-reducing valve is used to sense the pressure downstream of the modulating valve and adjust the main valve to maintain the predetermined, desired downstream pressure. If downstream pressures rise, the main valve needs to be partially closed to increase the head loss across the control valve. If downstream pressures drop, the valve will open.

*PRESSURE-RELIEF VALVES*--The pressure-relief valve senses the upstream pressure and opens if the pressure gets too high. Upon reduction of upstream pressures, the valve will tend to close and will completely close if pressures drop below the set point of the pilot valve.

*ALTITUDE VALVES*--The altitude valve is normally used to prevent water from overflowing storage reservoirs. These valves are nothing more than a variation of a pressure-reducing valve designed to shut when the pressure on the reservoir side of the valve reaches the desired level and open when the pressure on the distribution system side of the valve drops below a certain limit.

*FLOW-CONTROL VALVES*--The flow-control valves operate by sensing pressure upstream and downstream from an orifice in the pipeline and modulating the valve opening to maintain a constant pressure drop across the orifice.

*PUMP-CONTROL VALVES*--Pump-control valves allow pumps to be started and stopped against a closed valve. Generally, this type of valve is quite slow acting. The valve opens like a slow-acting pressure-relief valve on the pump start-up cycle. When the pump is to be stopped, a solenoid-operated pilot valve operates to close the main valve, with a mechanical linkage tripping a microswitch to shut off the pump motor when the control valve is almost closed.

## PUMPS*

The subject of pumps will be dwelt on very briefly. Most pumps being installed in public water supply wells at the present time are vertical turbine and a few submersible types. Submersible types seem to be becoming more common in smaller wells as replacements and especially where the well is not plumb.

The vertical turbine should be mounted on a good base or foundation, and it should be installed in such a manner that there is no vibration. A popular method of testing for vibration is to balance a coin on its edge on top of the motor. A small amount of vibration makes this impossible. Too few well pumps are being provided with gasoline, diesel, or natural gas engines for standby power so that water will be available when it may be needed most; that is, when a storm or some catastrophe has knocked out electric power. It is an excellent idea to provide this auxiliary power where possible.

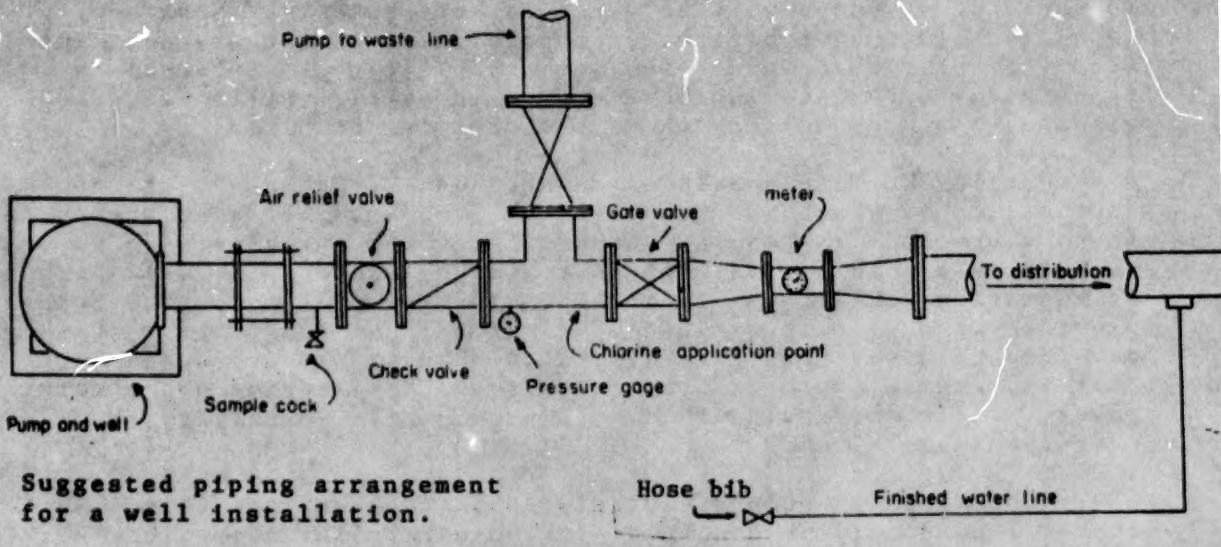
Where the water is pumped directly to the system, the pump discharge line should be equipped with an air relief valve, check valve, pump-to-waste line, pressure gauge, and gate valve. A meter on the pump discharge line is necessary if the water works is to be operated on a business-like basis, as it provides the information to make a comparison of "water pumped" to "water sold". It is helpful in finding leaks and determining cost of production. The air relief valve should be installed to eliminate the air which is in the pump column at the time the pump starts. If this air is pumped to the system and is unable to escape, the water may have a "milky" appearance when drawn from the spigot. Upon setting a few minutes, the air will dissipate from the water; however, air in the water will cause many complaints. Figure 1 shows a general piping layout for a deep well pump which includes the pump-to-waste line.

The pump-to-waste line provides a means whereby the yield can be determined exactly or may be estimated. Also this pump-to-waste line makes it easy to: (1) check to see if the pump is producing sand from the well; (2) flush the main leading to the distribution system (by backflow from the distribution tank); (3) pump to waste super-chlorinated water from the well after disinfection; (4) pump water to waste to help clear the well should complaints regarding turbidity arise; and (5) if for some reason a well has been out of use for a period of time, it can readily be pumped to waste before being used again.

In most cases, the pump operation should be controlled by automatic controls from either the water level in the elevated tank or from pressure actuated devices. By using automatic controls, the storage facilities can be kept more nearly full at all times. The advantage of this is obvious since fires or other disasters usually

*Source: Water Works Operators Manual, Bureau of Environmental Health, Alabama Department of Public Health, Third Edition, 1972, Chapter IX, pp. 13-17.

Figure 1




Suggested piping arrangement for a well installation.

occur without advance warning. Even where the automatic controls are used, the wells and pumps should be visited twice daily and probably more often.

## Pump Maintenance

The modern day pumps require only a relatively small amount of maintenance; however, some items such as oiling and greasing are required regularly. This is particularly true relative to the pump bearing oiler, since the rate changes with temperature. It should be set to drop 4 to 12 drops per minute each season of the year and checked on unusually warm or cold days. Too much oil should not be applied. The oil is not burned or used but passes the bearings and accumulates on top of the water in the well. Thus, it is wasteful and a large quantity on top of the water could more easily pull down into the pump suction or tail pipe and be pumped to the system. The oil reservoir for oil to lubricate the shaft bearings should be cleaned at frequent intervals to prevent water and sediment accumulations. Many pumps are provided with a reservoir in the pump head for oiling the top bearing. This oil should always be maintained at the proper indicated level and changed in accordance with the pump manufacturer's recommendations. In all cases, maintenance to pumping equipment should be accomplished in strict accordance with the manufacturer's recommendations.

All well and spring pumping facilities should be visited often and at least twice daily. During the visit, one should always listen for unusual sounds emanating from the well pump or pumps. An experienced operator can detect many developing problems by mechanical sounds. One should frequently check also for pump vibration.

This may be done by placing one hand on the top of the pump. In this manner, unusual vibrations may also be detected which may indicate bearing failure or similar situations. During visits when the pump or pumps are not running, one should listen for flowing water. A leaking check valve can easily be detected in this manner. The check valve should be repaired immediately since this is wasteful and poor operation.

## CENTRIFUGAL PUMP TROUBLES*

Difficulties are encountered with all machinery and centrifugal pumps are no exception to the rule. Every pump is tested at the factory and is mechanically and hydraulically correct when shipped. Occasionally a pump is damaged in shipment, however, most of the trouble experienced in the field is due to faulty installation.

A list of the most common troubles and their causes are given below:

1. NO WATER DELIVERED

   (a) Pump not primed.
   (b) Speed too low.
   (c) Discharge head too high.
   (d) Suction lift too high.
   (e) Impeller or suction pipe completely plugged up.
   (f) Wrong direction of rotation.
   (g) Air pocket in suction line.
   (h) Air leak in suction line or stuffing box.
   (i) Insufficient net positive suction head available.

2. NOT ENOUGH WATER DELIVERED

   (a) Air leak in suction line or stuffing box.
   (b) Speed too low.
   (c) Discharge head higher than anticipated (check friction loss).
   (d) Suction lifttoo high (check friction loss).
   (e) Impeller or suction pipe partially plugged up.
   (f) Wrong direction of rotation.
   (g) Insufficient net positive suction head available.
   (h) Foot valve to small.
   (i) Insufficient submergence of suction lift.
   (j) Wearing rings worn.

3. NOT ENOUGH PRESSURE DEVELOPED

   (a) Speed too low.
   (b) Excessive amount of air or gas in liquid.
   (c) Wrong direction of rotation.
   (d) Viscosity of liquid higher than anticipated.
   (e) Wearing rings worn.
   (f) Impeller diameter too small.

* From Centrifugal Pump Manual, pp 60-62, Published By the F. E. Myers Company, 400 Orange Street, Ashland, Ohio 44805.

4. PUMP WORKS FOR A WHILE, THEN LOSES PRIME

(a) Air leak in suction line or stuffing box.
(b) Excessive amount of air or gas in liquid.
(c) Air pocket in suction line.
(d) Water seal tube clogged.
(e) Water seal ring improperly located.
(f) Suction lift too high.
(g) Insufficient submergence of suction inlet.

5. PUMP REQUIRES EXCESSIVE POWER

(a) Speed too high
(b) Head lower than anticipated; pumps too much water.
(c) Specifit gravity or viscosity too high.
(d) Wrong direction of rotation.
(e) Misalignment.
(f) Stuffing box too tight.
(g) Rotating element rubbing or binding.
(h) Bent shaft.
(i) Wearing rings worn.

6. STUFFING BOX LEAKS EXCESSIVELY

(a) Packing is worn or improperly lubricated.
(b) Packing improperly installed.
(c) Incorrect type of packing.
(d) Shaft sleeve scored.
(e) Bent shaft.

7. PUMP IS NOISY OR VIBRATES

(a) Suction lift too high.
(b) Insufficient net positive suction head available.
(c) Impeller or suction pipe partially plugged up.
(d) Misalignment.
(e) Foundation not rigid.
(f) Lack of lubrication.
(g) Bearings worn.
(h) Rotating element out of balance.
(i) Bent shaft.